OBSERVATIONS OF VARIABLE STARS.

W. J. LUYTEN.

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Boek- en Steendrukkerij Eduard IJdo — Leiden.

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PROEFSCHRIFT

TER VERKRIJGING VAN DEN GRAAD VAN

Doctor in de Wis- en Sterrekunde

AAN DE RIJKSUNIVERSITEIT TE LEIDEN,

OP GEZAG VAN DEN RECTOR-MAGNIFICUS

R. P. VAN CALCAR,

HOOGLEERAAR IN DE FACULTEIT DER GENEESKUNDE,

VOOR DE FACULTEIT DER WIS- EN NATUURKUNDE TE VERDEDIGEN

OP

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DOOR

WILLEM JACOB LUYTEN,

GEBOREN TE SEMARANG.

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CONTENTS.

CHAPTER I.

Introduction.

In September 1915, the writer, then at Deventer, took to observing variable stars on the instigation of Prof. NYLAND and continued these observations till October 1919. In the beginning only bright stars, mainly of the Cepheid-type, could be observed by means of a fieldglass, but later on, when the writer came in possession, first of a $1^1/_2$-inch, later on, of a 3-inch telescope, and in the autumn of 1918 was invited to Leiden by Prof. DE SITTER and allowed to use the 6-in equatorial, the observing list was extended to fainter variables and accordingly many stars of the long period class were kept under observation.

In this paper, only a short résumé of the results will be given, as by the kind permission of Prof. W. DE SITTER, Director of Leiden Observatory, the observations will be published in full, together with the discussion, in "Annalen van de Sterrewacht te Leiden", publication that will hereafter be referred to as "Annalen".

Accordingly no detailed description of the observing method need be given here; it is only stated, that NYLAND's interpolation method (Astr. Nach. 3695) was used almost throughout; only sometimes ARGELANDER's step-method had to be followed As the writer entered the University of Amsterdam, in September 1916, the observations, which, previous to that date, were all made at Deventer, were then

mostly made at Amsterdam, and only at Deventer during the holidays. During this time the 6-in Equatorial of the Rev. J. Stein was sometimes used by his kind permission. In September 1918 the writer moved to Leiden University and observations were accordingly made at that Observatory till July 1919, when a stop was made with the observing of faint stars and from that date on, until Oct. 1919, only bright stars were observed by means of a field-glass, the writer then staying at the Royal Observatory, Greenwich.

During the whole time of observation about 13500 obs. were secured, divided as follows over the different classes.

Class I—II.	(Nova and long period).	7000
Class III.	(Irregular).	2700
Class IV.	(Cepheids).	3300
Class V.	(Algolstars).	500

In the first four Chapters, the observations of variables belonging to Class I—III wil be dealt with, while the other variables will be treated in a subsequent chapter (V).

It may also be stated here, that the writer's eye seemed to be more sensitive than an average one, so that very faint stars could be observed. F. i. the minima of R Coronae, 13·2 and 13·6 were both observed in a 3-in telescope. These magnitudes proved to be the same as those found by Professor Nijland with the Utrecht 10-in.

The limits of visibility were:

$1\frac{1}{2}$-in $10^{m}.8$; 3-in $13^{m}.7$ 6-in Amsterdam $14^{m}.2$

all from Harvard sequences and 6-in Leiden $14^{m}.8$ from North Polar Sequence.

CHAPTER II.

The Comparison Stars.

For nearly all stars of class I—III, that were observed, sequences of comparison stars were available in the Harvard Annals (Vols. 37, 57, 63) and, but for a few exceptional cases, these were always used. When no Harvard sequence was available, or where it was found necessary to deviate from it, the magnitudes of the comparison stars used, were taken from H.A. 50, 54, or 74 when possible.

Only in the case of V 58 = AD Cygni and V 63 = AI Cygni, the magnitudes of the comparison stars were derived from estimates, but they were reduced to the Harvard system, by means of surrounding stars occuring in H.A. 54. Details about the comparison stars will be found in the extensive publication in the Annals of Leiden Observatory.

CHAPTER III.

The Observations.

These are printed in full in "Annalen", in a table giving Julian Day and adopted magnitude, no more columns having been added for reasons explained there.

The Maxima and Minima, derived from these observations, are shown in the following Tables, that are however also printed in "Annalen". Table I gives the required data for stars of class II, Table II those for class III (Irregular).

In both Tables the first 6 columns contain:

1. the Designation, according to Pickering, southern stars being represented by italics.
2. the Latin Capital of the variable, according to Argelander, and its number after Nijland's proposal (Astr. Nach. 4765).
3. the total number of observations for each star
4. the phase M = max. m = min.
5. the Julian Day of Max. or Min.
6. the magnitude attained.

In Table I, a seventh column is added, containing the differences O — C between the observed epochs and the prediction in Hartwig's Vierteljahrsschrift, whenever this was available.

For some strongly coloured stars with small range, which is only about as large as the expected observational error (ρ Persei, R Lyrae) the times of Max. and Min. for these

two stars have nevertheless been included, although they are not very trustworthy: only the comparison with other observers can ascertain, whether they are real or not.

At the end of Table II are given the maxima (or an indication relating to it) of four variables of the U Geminorum-class: V 19 = SS Cygni however, being the only one regularly observed.

Design.	Variable.	No. Obs.	Phase.	Date J. D. 242.	Mag.	O — C
001046	X Androm.	6	M.	1653	$9^{m}.0$	+ 22
001726	T Androm.	13	M.	1618	8·8	+ 19
			M.	1902	8·7	+ 27
001755	T Cassiop.	53	M.	1377	8·5	— 3
			m.	1686	11·7	
			M.	1859	7·8	+ 39
001838	R Androm.	93	M.	1057	7·5	— 12
			M.	1432	7·5	— 53
			m.	1730	14·1	
			M.	1840	6·7	— 62
001909	S Ceti.	30	M.	1464	8·5	— 46
003179	Y Cephei.	13	M.	1503	10·0	— 31
			M.	1822	9·4	— 45
004047	U Cassiop.	38	M.	1338	8·6	— 19
			M.	1626	8·5	— 9
			M.	1897	9·1	— 16
004181	V 16 = RX Cephei.	51	M.	1317	7·4 [5]	+ 17
			m.	1363	7·6 [5]	— 2
			M.	1437	7·4 [5]	+ 7
			m.	1464	7·6	— 31
004435	V Androm.	41	M.	1122	9·8	+ 1
			M.	1602	9·3	— 37
			M.	1866	9·5	— 22
004535	V 10 = RR Andr.	16	M.	1437	9·4	— 56
			M.	1767	8·4	— 60
004958	W Cassiop.	39	M.	1446	9·3	— 19
			m.	1662	11·9	
			M.	1888	9·1	+ 19
			m.	2067	11·8	
010102	Z Ceti.	14	M.	1494	8·9	— 1
			M.	2858	9·3	— 3
011272	S Cassiop.	22	M.	1794	8·7	+ 82
012350	V 18 = RZ Persei.	5	M.	1730	9·4	— 20
012502	R Piscium.	48	M.	1157	7·5	— 18
			M.	1500	9·3	— 21
			M.	1859	8·5	— 9
013338	Y Androm.	15	M.	1459	9·7	+ 26
014958	X Cassiop.	28	m.	1691	13·2	
			M.	1897	11·1	+ 146
			m.	2066	13·1	

Design.	Variable.	No. Obs.	Phase.	Date J.D. 242.	Mag.	O — C
015354	U Persei.	67	M.	1186	$8^m.1$	— 3
			m.	1360	10·5	+ 13
			M.	1476	8·0	— 28
			m.	1690	11·0	
			M.	1800	8·2	— 17
			m.	2004	10·4	
021024	R Arietis.	80	M.	1135	7·7	
			M.	1316	8·4	— 16
			M.	1494	9·7	— 25
			m.	1592	12·5	
			M.	1675	8·2	— 31
			M.	1874	8·9	— 19
			m.	1973	13·1	
021143*a*	W Androm.	57	M.	1331	7·4	+ 2
			m.	1592	13·6	
			M.	1754	8·0	+ 29
			m.	1988	13·9	
021403	o Ceti.	218	M.	1177	3·8	— 25
			m.	1394	9·2	— 12
			M.	1508	3·4	— 25
			m.	1725	9·1	
			M.	1860	4·0	— 4
			m.	2050	8·8	
			M.	2175	3·2	— 20
022000	R Ceti.	19	M.	1218	8·2	— 17
			M.	1536	8·0	— 33
			M.	1865	8·0	— 37
022150	V 10 = RR Persei.	9	M.	1524	9·3	+ 14
022813	U Ceti.	8	M.	1497	8·4	— 24
023080	V 10 = RR Cephei.	6	M.	1674	10·0	— 8
023133	R Trianguli.	88	M.	1208	7·2	+ 7
			M.	1477	6·1	+ 7
			m.	1612	11·8	
			M.	1732	6·8	— 7
			m.	1883	11·1	
			M.	1998	5·8	— 10
024217	T Arietis.	31	M.	1705	8·6	+ 42
031401	X Ceti.	41	M.	1180	9·0	— 5
			M.	1512	9·0	— 25
			m.	1620	12·9	

TABLE I.

Design.	Variable.	No. Obs.	Phase.	Date J.D 242.	Mag.	O — C
031401	X Ceti.	41	M.	1664	$9^m.1$	— 50
			M.	1664	9·1	— 50
			M.	1868	8·7	— 22
			M.	1965	12·6	
032335	R Persei.	41	M.	1219	8·9	— 16
			M.	1430	8·9	— 14
			m.	1530	13·2	— 23
			M.	1620	8·9	— 32
			m.	1747	13·6	
			M.	1835	8·8	— 26
			m.	1908	12·7	
042209	R Tauri.	10	M.	1684	9·1	— 21
043065	T Camelopardi.	65	M.	1364	8·2	+ 20
			m.	1582	12·7	
			M.	1748	7·4	+ 34
			m.	1940	13·4	
043274	X Camelopardi.	90	M.	1367	8·3	— 19
			m.	1452	13·0	+ 3
			M.	1517	8·2	— 15
			m.	1594	12·7	+ 3
			M.	1656	8·2	— 15
			m.	1728	12·8	
			M.	1798	8·2	— 17
			m.	1888	13·3	
			M.	1949	9·2	— 7
			m.	2017	12·9	
045514	R Leporis.	41	M.	1215	7·7	+ 80
			M.	2015	7·3	+ 7
050849	UX Aurigae.	4	M.	1675	8·2	— 49
050953	R Aurigae.	37	M.	1522	7·4	— 20
			m.	1745	13·7	
			M.	2013	8·4	+ 12
052036	W Aurigae.	4	M.	1528	9·5	— 20
052404	S Orionis.	53	M.	1239	8·2	+ 50
			M.	1632	7·8	+ 24
			m.	1820		
053068	S Camelopardi	64	M.	1355	8·8	
			m.	1403	9·1	
			M.	1435	8·2	— 39
			m.	1606	10·5	

Design.	Variable.	No. Obs	Phase.	Date J.D. 242.	Mag.	O — C
053068	S Camelopardi	64	M.	1742	$8^{m}.5$	— 21
			m.	1906	10·6	
054920	U Orionis.	29	m.	1630	12·0	
			M.	1783	7·0	— 66
			m.	2019	12·2	
055353	Z Aurigae.	21	M.	1491	9·8	— 20
060450	X Aurigae.	30	m.	1440	12·9	+ 44
			M.	1509	9·0	+ 41
			m.	1594	12·9	+ 35
			M.	1670	8·5	+ 39
			m.	1766	12·9	
061647	V Aurigae.	4	M.	1522	9·8	— 10
063558	S Lyncis.	4	M.	1750	9·7	+ 20
064030	X Geminorum.	33	M.	1314	8·6	+ 3
			m.	1471	13·0	+ 48
			M.	1590	8·7	+ 17
			M.	1872	8·3	+ 9
			m.	1998	13·4	
065111	Y Monocerotis.	16	M.	1261	9·1	— 24
			M.	1501	9·9	— 13
065355	R Lyncis.	51	M.	1314	8·8	— 33
			M.	1693	7·8	— 29
			m.	1916	14·0	
070122*a*	R Geminorum.	39	M.	1171	6·8	+ 28
			M.	1490	6·5	+ 27
			m.	1911	7·8	+ 3
071713	V Geminorum.	31	M.	1295	8·5	+ 17
			M.	1576	8·2	+ 22
			m.	2034	12·0	
072708	S Can. Min.	21	M.	1521	7·5	— 26
073508	U Can. Min.	11	M.	1229	9·6	+ 9
073723	S Geminorum.	29	M.	1310	8·6	— 34
			M.	1594	9·7	— 44
			M.	1996	9·0	+ 104
074323	T Geminorum.	24	M.	1375	8·8	— 59
			M.	1657	8·3	— 65
			M.	1962	8.3	— 125
081112	R Cancri.	39	M.	1345	6·9	— 100
			m.	1568	10·8	
			M.	1692	6.9	— 186

TABLE I.

Design.	Variable.	No. Obs.	Phase.	Date J. D. 242.	Mag.	O — C
081112	R Cancri.	39	m.	1899	$11^{m}.7$	
			M.	2067	7·4	— 170
081617	V Cancri.	14	M.	1721	8·0	— 6
083350	X Urs. Maj.	10	M.	1265	9·7	— 52
085008	T Hydrae.	15	M.	1707	7·7	— 15
			M.	2000	8·0	— 11
093934	R Leo. Min.	51	M.	1267	7·6	+ 11
			M.	1627	7·0	— 14
			m.	1844	12·4	
			M.	1989	6·5	— 23
094211	R Leonis.	111	m.	1310	10·1	+ 82
			M.	1420	6·2	+ 48
			m.	1620	10·2	
			M.	1750	5·5	+ 65
			m.	1932	10·5	
			M.	2062	7·1	+ 65
095421	V Leonis.	9	M.	1655	8·6	+ 1
103769	R Urs. Majoris.	117	M.	1150	7·6	— 4
			M.	1452	7·5	— 1
			m.	1631	12·8	
			M.	1747	7·4	— 8
			m.	1939	12·9	
			M.	2050	7·9	— 7
121418	R Corvi.	29	M.	1259	7·2	— 53
			M.	1591	7·8	— 40
122532	T Can. Ven.	8	m.	1768	12·8	
			M.	1870	9·7	— 17
123160	T Ursae Majoris.	99	M.	1253	6·8	— 48
			m.	1427	12·9	— 23
			M.	1494	7·8	— 64
			m.	1683	13·2	
			M.	1773	8·4	— 34
			m.	1904	12·4	
			M.	2018	6·8	— 46
123307	R Virginis.	83	m.	1250	11·2	— 37
			M.	1322	7·3	— 34
			m.	1393	11·1	— 40
			M.	1602	7·0	— 46
			m.	1691	10·4	
			M.	1741	7·2	— 54

Design.	Variable.	No. Obs.	Phase.	Date J.D. 242.	Mag.	O — C
123307	R Virginis.	83	m.	1988	$11^m.3$	
			M.	2052	7·1	— 35
123961	S Urs. Majoris.	94	M.	1329	8·3	— 62
			m.	1466	11·5	— 48
			M.	1528	8·3	— 89
			m.	1677	11·5	
			M.	1790	8·3	— 61
			m.	1894	11·3	
			M.	2002	8·2	— 79
124606	U Virginis.	34	M.	1379	8·4	+ 21
			M.	1590	8·2	+ 25
			m.	1698	13·0	
131546	V Can. Venat.	73	m.	1406	8·6	+ 14
			M.	1468	6·7	— 17
			m.	1600	8·6	
			M.	1667	6·8	— 10
			m.	1780	8·7	
			M.	1862	6·8	— 7
			m.	1960	8·6	
			M.	2064	6·9	+ 3
132202	V Virginis.	6	M.	1705	8·9	— 26
132422	R Hydrae.	19	M.	1350	6·2	— 126
132706	S Virginis.	32	M.	1255	7·1	+ 3
			M.	1625	7·5	+ 14
133273	T Urs. Min.	50	M.	1371	9·0	+ 13
			m.	1551	13·4	
			M.	1693	9·3	— 31
			m.	1890	13·4	
			M.	2008	10·0	— 33
134440	R Can. Venat.	65	M.	1208	8·0	— 29
			m.	1374	11·5	— 21
			M.	1541	7·8	— 24
			m.	1693	11·6	
			M.	1861	8·0	+ 3
			m.	2022	11·4	
140113	Z Bootis.	20	M.	1433	9·9	— 63
			M.	1696	9·4	— 70
141567	U Urs. Min.	47	M.	1189	8·4	— 36
			M.	1482	9·0	— 70
			M.	1843	7·8	— 36

TABLE I.

Design.	Variable.	No. Obs.	Phase.	Date J. D. 242.	Mag.	O — C
141567	U Urs. Min.	47	m.	2017	$12^{m}.2$	
141954	S Bootis.	54	M.	1331	8·5	+ 8
			M.	1594	8·5	— 2
			m.	1750	13·0	
			M.	1882	8·4	+ 31
142205	V 11 = RS Virginis.	29	M.	1370	8·2	— 80
			M.	1718	8·1	— 87
142584	R Camelopardi.	76	M.	1277	8·2	+ 48
			m.	1432	13·1	— 38
			M.	1546	8·8	+ 47
			m.	1697	13·3	
			M.	1838	8·4	+ 47
			m.	1980	13·2	
142539	V Bootis.	84	M.	1296	7·7	+ 1
			m.	1478	10·7	+ 38
			M.	1565	7·6	+ 11
			m.	1745	10·1	
			M.	1818	7·7	+ 6
			m.	1997	10·2	
143227	R Bootis.	87	M.	1257	7·4	— 22
			m.	1388	11·0	— 9
			M.	1486	6·8	— 16
			m.	1607	11·7	
			M.	1700	7·5	— 25
			m.	1831	12·2	
			M.	1919	6·7	— 30
151714	S Serpentis.	36	M.	1463	8·6	— 33
			m.	1661	13·4	
			M.	1822	8·3	— 44
			m.	2012	13·5	
151731	S Coronae.	65	M.	1271	8·0	+ 7
			m.	1497	12·7	
			M.	1609	7·3	— 16
			m.	1840	12·5	
			M.	1980	6·6	— 7
153378	S Urs. Min.	64	M.	1295	8·4	— 20
			m.	1494	11·5	+ 9
			M.	1612	8·4	— 36
			m.	1792	11·4	
			M.	1915	8·3	— 46

Design.	Variable.	No. Obs.	Phase.	Date J.D. 242.	Mag.	O — C
154536	X Coronae.	43	M.	1305	$9^m.6$	— 27
			m.	1433	<13·2	— 42
			M.	1522	9·8	— 53
			m.	1648	13·6	
			M.	1737	9·2	— 81
			m.	1877	13·4	
			M.	1978	9·2	— 83
154615	R Serpentis.	150	M.	0967	7·0	— 14
			M.	1311	5·9	— 28
			m.	1544	13·5	— 3
			M.	1675	6·6	— 23
			m.	1908	13·5	
			M.	2048	7·3	— 8
154639	V Coronae.	31	M.	1554	8·1	— 91
			M.	1922	7·4	— 88
155229	Z Coronae.	12	M.	1440	11·0	+ 62
160210	U Serpentis.	55	M.	1384	8·5	— 3
			m.	1539	12·9	+ 14
			M.	1637	8·9	+ 12
			m.	1770	12·6	
			M.	1860	8·5	— 2
			m.	2012	12·5	
160325	V 24 = SX Herculis.	75	M.	1372	7·9	— 36
			m.	1430	8·8	— 14
			M.	1471	7·9	— 37
			m.	1527	8·7	— 27
			M.	1574	8·2	— 34
			m.	1626	8·8	
			M.	1671	8·0	— 38
			m.	1730	8·8	
			M.	1774	8·0	— 36
			m.	1825	8·8	
			m.	2037	8·8	
			M.	2071	7·8	— 41
161122b	S Scorpii.	4	M.	1758	9.5	+ 28
160625	V 13 = RU Herculis.	7	M.	2032	8·3	— 51
161138	W Coronae.	36	M.	1316	8·2	+ 24
			M.	1548	8·5	+ 18
			M.	1799	9·2	+ 31
			M.	2032	8·0	— 1

Design.	Variable.	No. Obs.	Phase.	Date J. D. 242.	Mag.	O — C
162112	V Ophiuchi.	27	M.	1498	$8^{m}.1$	+ 108
			m.	1376	9·6	
			M.	1781	8·1	+ 88
			m.	1990	9·7	
162119	U Herculis.	38	M.	1449	8·5	+ 23
			m.	1695	13·1	
			M.	1860	7·6	+ 24
162807	V 19 = SS Herc.	72	M.	1370	9·3	+ 21
			m.	1438	12·1	+ 33
			M.	1480	9·0	+ 23
			m.	1545	12·2	+ 33
			M.	1591	9·4	+ 27
			m.	1657	12·2	+ 37
			M.	1695	10·4	+ 23
			m.	1752	12·2	+ 24
			M.	1802	9·9	+ 22
			m.	1869	12·2	+ 34
			M.	1920	9·5	+ 33
			m.	1968	12	+ 25
			M.	2020	9·5	+ 25
			m.	2077	12·2	+ 27
163137	W Herculis.	34	M.	1505	8·2	— 5
			M.	1780	8·1	— 15
			m.	1938	13·6	
			M.	2064	8·8	— 15
163266	R Draconis.	103	M.	0955	7·4	— 2
			M.	1191	8·0	— 12
			m.	1339	12·5	+ 3
			M.	1451	7·2	+ 3
			m.	1590	12·8	+ 19
			M.	1687	8·3	— 6
			m.	1825	12·9	
			M.	1927	7·8	— 11
164055	S Draconis.	46	M.	1198	8·3	— 8
164715	S Herculis.	55	m.	1433	12·5	— 49
			M.	1571	8·5	— 65
			m.	1711	12·5	
			M.	1896	8·2	— 58
			m.	2020	12·1	
165631	V 14 = RV Herculis.	17	M.	1537	10·4	+ 43

Design.	Variable.	No. Obs.	Phase.	Date J. D. 242	Mag.	O — C
171401	Z Ophiuchi.	49	M.	1342	$8^{m}.0$	+ 18
			m.	1543	12·6	— 38
			M.	1646	8·5	— 30
			m.	1880	12·0	
			M.	1998	8·4	— 27
171723	V 11 = RS. Herc.	43	M.	1423	8·5	— 46
			M.	1647	8·5	— 42
			m.	1763	12·5	
			M.	1874	7·8	— 35
			m.	1984	13·4	
			M.	2056	9·4	— 63
175519	V 17 = RY Herc.	23	M.	1531	9·4	— 6
			m.	1640	13·5	
180531	T Herculis.	84	M.	1394	8·2	+ 20
			m.	1470	13·2	+ 9
			M.	1537	7·8	— 2
			m.	1629	12·9	
			M.	1718	7·7	+ 4
			m.	1820	13·2	
			M.	1881	8·6	+ 11
			m.	1963	13	
			M.	2045	7·8	+ 10
181103	V 17 = RY Ophiuchi.	22	M.	1441	9·4	— 55
			m.	1807	12·8	
181136	W Lyrae.	70	M.	1309	7·6	+ 18
			M.	1497	7·6	+ 9
			m.	1590	12·4	+ 6
			M.	1670	7·6	— 14
			m.	1791	12·4	
			M.	1894	7·7	+ 7
			m.	1991	12·7	
			M.	2104	8·6	+ 27
182224	V 22 = SV Herc.	15	M.	1530	9·6	+ 5
			m.	1670	13·5	
			m.	1882	13·4	
			M.	1988	9·8	— 17
182306	T Serpentis.	11	M.	1726	9·1	— 27
183225	V 18 = RZ Herc.	29	M.	1433	9·4	— 7
			m.	1649	13·2	
			M.	1785	10·6	+ 17
			m.	1950	12·5	

Design.	Variable.	No. Obs.	Phase.	Date J. D. 242.	Mag.	O — C
183308	X Ophiuchi.	123	M.	1127	$6^{m}.9$	+ 5
			m.	1290	8·9	+ 6
			M.	1469	7·0	+ 12
			m.	1618	8·9	
			M.	1800	6.6	+ 8
			m.	1982	8·7	
			M.	2138	6·5	+ 11
190108	R Aquilae.	119	M.	1082	6·0	— 97
			m.	1280	11·6	
			M.	1384	6·0	— 126
			m.	1587	11·6	
			M.	1679	6·0	— 164
			m.	1864	10·8	
			M.	1988	5·5	— 188
191007	W Aquilae.	9	M.	1452	8·4	— 3
192745	V 60 = AF Cygni.	217	m.	1020	7·8	+ 17
			M.	1062	6·6	+ 25
			m.	1118	7·6	+ 20
			M.	1151	6·8	+ 19
			m.	1207	7·6	+ 14
			M.	1236	6·7	+ 9
			m.	1278	7·6	— 10
			M.	1316	6·7	— 6
			m.	1371	7·4	— 12
			M.	1405	6·8	— 12
			m.	1440	7·7	— 38
			M.	1475	6·8	— 39
			m.	1554	7·6	— 19
			M.	1654	7·2	+ 47
			m.	1694	7·6	
			M.	1725	7·2	+ 23
			m.	1760	7·5	
			M.	1799	7·1	+ 2
			m.	1828	7·6	
			M.	1876	6·9	— 25
			m.	1914	7·6	
			M.	1968	6·8	— 19
			m.	2016	7·6	
			M.	2054	7·0	— 28
			m.	2132	7·6	

Design.	Variable.	No. Obs.	Phase.	Date J. D. 242.	Mag.	O — C
192928	V 32 = TY Cygni.	5	M.	1676	$9^m.7$	— 43
193449	R Cygni.	106	M.	1077	7·2	— 15
			m.	1326	13·2	— 43
			M.	1484	8·5	— 34
			m.	1747	13·8	
			M.	1898	6·7	— 46
194048	V 12 = RT Cygni.	135	M.	1169	7·3	+ 24
			M.	1355	7·3	+ 10
			m.	1476	11·9	+ 26
			M.	1564	8·0	+ 30
			m.	1659	11·9	
			M.	1759	7·3	+ 35
			m.	1856	11·7	
			M.	1949	7·5	+ 35
			m.	2034	11·7	
			M.	2114	7·3	+ 10
194348	V 28 = TU Cygni.	24	M.	1489	10·7	+ 35
			M.	1692	9·6	+ 20
194604	X Aquilae.	19	M.	1685	8·6	— 53
			m.	1873	12·7	
			M.	2023	8·2	— 63
194632	χ Cygni.	158	M.	0878	5·6	— 17
			M.	1287	5·4	— 13
			m.	1530	13·7	— 6
			M.	1687	4·8	— 21
			m.	1926	13·4	
			M.	2093	5·8	— 23
195849	Z Cygni.	86	M.	1111	8·3	— 24
			M.	1349	8·3	— 40
			M.	1631	9·5	— 21
			m.	1787	13	
			M.	1914	9·6	— 1
			m.	2054	12·7	
200357	S Cygni.	20	M.	1525	10·8	— 42
			M.	1832	10·9	— 61
200514	R Capricorni.	16	M.	1431	10·2	+ 56
200715*a*	S Aquilae.	26	m.	1501	12·2	— 36
			M.	1564	9·0	— 34
			M.	1715	9·1	— 49
			m.	1760	11·2	

TABLE I.

Design.	Variable.	No. Obs	Phase.	Date J. D. 242.	Mag.	O — C
200916	R Sagittae.	22	m.	1496	$10^{m}.1$	
200906	Z Aquilae.	19	M.	1478	9·4	— 25
201008	R Delphini.	24	M.	1522	8·2	— 49
			M.	1818	9·0	37
201130	V 24 = SX Cygni.	16	M.	1467	9·3	+ 37
201647	U Cygni.	97	M.	1321	7·2	+ 21
			M.	1558	10·4	+ 23
			M.	1812	7·2	+ 48
			m.	2033	9·9	
202924	V 20 = ST Cygni.	12	m.	1675	12·7	
203816	S Delphini.	25	M.	1426	9·2	— 65
			m.	1842	11.0	
			M.	1966	9·4	— 80
			m.	2047	10·7	
203847	V Cygni.	23	M.	1639	8·4	+ 19
			m.	1900	13·5	
204016	T Delphini.	29	M.	1384	9·3	— 11
204405	T Aquarii.	44	m.	1481	12·9	— 27
			M.	1560	7·7	— 35
			M.	1776	7·7	— 23
			m.	1872	12·8	
			M.	1958	8·4	— 39
205030*a*	V 37 = UX Cygni.	11	m.	1648	13·0	
205923	R Vulpeculae.	90	M.	1252	8·3	+ 10
			M.	1387	8·6	+ 9
			m.	1460	12·0	+ 7
			M.	1522	8·3	+ 7
			m.	1592	12·7	+ 2
			M.	1657	8·3	+ 5
			m.	1730	12·6	
			M.	1794	8·7	+ 5
			m.	1872	12·6	
			M.	1931	8·8	+ 5
			m.	2011	12·7	
			M.	2074	8·2	+ 12
210868	T Cephei.	205	m.	1032	10·6	+ 14
			M.	1237	5·9	+ 11
			m.	1415	10·5	+ 10
			M.	1595	6·3	— 18
			m.	1804	10·0	

Design.	Variable.	No. Obs.	Phase.	Date J.D. 242.	Mag.	O C
210868	T Cephei.	205	M.	1980	$6^m.4$	− 20
210812	R Equulei.	10	M.	1588	10·0	+ 1
				1838	9·7	− 9
213244	V 56 = AB Cygni.	44	M.	1322	8·0	+ 90
213678	S Cephei.	30	M.	1443	9·9	+ 32
			m.	1683	12·6	
			M.	1942	9·7	+ 41
213745	V 13 = RU Cygni.	17	M.	1543	7·8	+ 122
215605	V Pegasi.	5	M.	1836	8·9	− 1
222439	S Lacertae.	55	M.	1251	8·3	+ 69
			M.	1484	8·5	+ 64
			m.	1624	12·9	
			M.	1735	8·6	+ 77
			m.	1842	12·7	
			M.	1974	8·0	+ 88
223841	R Lacertae.	25	M.	1427	9.6	− 6
			M.	1732	9·5	− 1
			M.	2041	9·4	+ 11
225914	V 15 = RW Pegasi.	16	M.	1520	10·7	+ 24
230110	R Pegasi.	37	M.	1223	8·4	− 7
			m.	1450	13·3	− 5
			M.	1593	7·9	− 14
			m.	1817	13·3	
			M.	1977	9·2	− 13
230759	V Cassiopejae.	64	M.	1261	7·8	− 50
			M.	1483	7·2	− 59
			m.	1599	12·8	
			M.	1706	8·1	− 67
			m.	1838	12·8	
			M.	1942	8·1	− 61
			m.	2068	11·8	
233451	V 22 = SV Cassiopejae	61	M.	1253	9·1	+ 59
			m.	1397	9·6	+ 53
			M.	1516	7·4	+ 50
			m.			
			M.	1839	8·7	+ 101
233815	R Aquarii.	35	M.	1504	6·4	− 89
			M.	1923	6·5	− 63
234716	Z Aquarii.	9	M.	1493	8·5	+ 8

TABLE I.

Design.	Variable.	No Obs	Phase	Date J.D. 242.	Mag.	O — C
235182	V Cephei.	49	M.	1186	$6^{m}.3$	+ 8
			m.	1360	6·7	— 24
			M.	1456	6·2	— 84
235350	R Cassiopejae.	107	M.	1244	6·8	— 10
			m.	1516	12·9	+ 18
			M.	1663	6·4	— 17
			m.	1942	13·3	
235851	Y Cassiopejae.	10	M.	1404	9·2	+ 80

Design.	Variable.	No. Obs.	Phase.	J. D.	Mag.
001620	T Ceti.	54	m.	1455	$6^{m}.8$
			M.	1475	5·9
			m.	1503	6·4
			M.	1523	5·8
			M.	1842	5·3
025838	ρ Persei.	149	m.	1087	3·9
			M.	1122	3·7
			m.	1222	4·0
			M.	1244	3·8
033362	U Camelopardi.	85	M.	1375	8·0
			m.	1467	8·9
			M.	1477	8·3
			m.	1536	8·7
			M.	1599	7·5
			m.	1722	9·0
			M.	1839	7·4
			m.	1968	8·6
			M.	2049	7·6
053920	Y Tauri.	16	M.	2002	7·7
103212	U Hydrae.	89	M.	1200	5·3
			m.	1239	5·7
			M.	1353	5·1
			m.	1361	5·4
			M.	1646	5·0
124045	Y Can. Venat.	29	M.	1633	5·1
			m.	1754	5·6
			M.	1776	5·2
154428	R Coronae.	281	m.	1375	13·2
			M.	1435	9·7
			m.	1479	13·6
			M.	1536	10·0
			m.	1590	11·0
			M.	1623	8·8
			m.	1653	9·6
			M.	1686	8·3
			m.	1694	8·7
155846	X Herculis.	136	m.	1464	7·2
			M.	1480	7·0
			m.	1490	7·2
			M.	1502	7·0

TABLE II.

Design.	Variable.	No. Obs.	Phase.	J. D.	Mag.
155846	X Herculis.	136	m.	1514	$7^m.2$
			M.	1541	7·0
			M.	1627	6·9
			m.	1648	7·2
			M.	1659	7·0
162542	g Herculis.	309	M.	0942	5·1
			m.	0977	5·4
			M.	1004	5·2
			m.	1034	5·4
			M.	1117	5·1
			m.	1151	5·4
			M.	1182	5·1
			m.	1224	5·5
			M	1261	5·2
			m.	1322	5·4
			M.	1361	4·8
			m.	1391	5·4
			M.	1430	4·7
			m.	1463	5·3
			M.	1491	4·9
			m.	1502	5·1
			M.	1511	4·8
			m.	1581	5·3
			M.	1650	4·9
			m.	1714	5·4
			M.	1763	4·9
			m.	1812	5·4
			M.	1840	5·0
			M.	2070	5·3
			m.	2113	5·6
			M.	2158	4·9
163172	R Ursae Min.	23	m.	1545	10·0
184205	R Scuti.	347	m.	0785	7·0
			M.	0826	4·8
			m.	1018	5·8
			M.	1033	5·3
			m	1079	7·3
			M.	1118	5·0
			m.	1133	6·0
			M.	1172	5·0

Design.	Variable.	No. Obs.	Phase.	J. D.	Mag.
184205	R Scuti	347	m.	1207	$6^m.2$
			M.	1271	4·7
			m.	1316	6·0
			M.	1330	5·3
			m.	1377	7·5
			M.	1414	5·5
			m.	1437	6·2
			M.	1449	5·4
			m.	1498	7·2
			M.	1566	5·7
			m.	1616	6·2
			M.	1725	4·9
			m.	1788	7·4
			M.	1849	5·4
			m.	1915	6·0
			M.	1994	4·7
			m.	2090	7·5
			M.	2139	4·8
185343	R Lyrae.	281	M.	0963	4·1
			m.	0993	4·3
			M.	1003	4·1
			m.	1032	4·2
			M.	1046	4·1
			m.	1080	4·4
			M.	1100	4·2
			m.	1124	4·4
			M.	1150	4·1
			m.	1172	4·3
			M.	1185	4·1
			m.	1202	4·3
			M.	1218	4·1
			m.	1236	4·2
			M.	1257	4·1
			m.	1301	4·3
			M.	1333	4·1
			m.	1371	4·3
			M.	1395	4·1
			m.	1444	4·4
			M.	1460	4·2
			m.	1490	4·3

Design.	Variable.	No. Obs.	Phase.	J. D.	Mag.
185343	R Lyrae.	281	M.	1509	$4^{m}.1$
			m.	1529	4·3
			M.	1551	4·2
			m.	1576	4·3
			M.	1599	4·2
			m.	1628	4·4
			M.	1657	4·0
			m.	1705	4·3
			M.	1738	4·1
			m.	1754	4·3
			M.	1768	4·1
			m.	1780	4·4
200938	V 11 = RS Cygni.	92	M.	1237	8·4
			m.	1268	9·0
			M.	1294	8·4
			m.	1315	8·7
			M.	1399	7·7
			m.	1573	7·0
202732	V 58 = AD Cygni.	55	M.	1264	9·4
			m.	1318	9·8
			M.	1345	9·3
			m.	1382	9·8
			M.	1402	9·6
			m.	1440	10·2
			M.	1512	9·4
			m.	1552	9·8
			M.	1605	9·3
			m.	1705	9·8
			M.	1787	9·5
			m.	1864	9·9
			M.	1897	9·2
202732*a*	V 63 = AI Cygni.	64	M.	1162	8·7
			m.	1237	9·1
			M.	1285	8·8
			m.	1371	9·5
			M.	1394	9·1
			m.	1434	9·4
			M.	1462	9·1
			m.	1487	9·5
			M.	1509	9·2

Design.	Variable.	No. Obs.	Phase.	J. D.	Mag.
202732*a*	V 63 = AI Cygni.	64	m.	1544	$9^{m}.7$
			M.	1586	9·1
			m.	1674	10·0
213244	W Cygni.	280	M.	1033	5·9
			m.	1108	6·8
			M.	1156	5·5
			m.	1226	6·6
			M.	1303	5·4
			m.	1382	6·7
			M.	1436	5·9
			m.	1525	6·8
			M.	1574	5·8
			m.	1652	7·6
			M.	1748	6·4
			m.	1814	6·9
			M.	1862	5·9
			m.	1928	7·7
			M.	2028	5·9
213843	V 19 = SS Cygni.	258	M.	1405	8·6
			M.	1434	9·6
			M.	1463	8·4
			M.	1522	8·4
			M.	1574	8·4
			M.	1625	8·4
			M.	1688	8·4
			M.	1747	8·2
			M.	1812	8·4
			M.	1845	8·4
			M.	1904	8·4
			M.	1983	8·4
			M.	2016	8·4
			M.	2042	8·4
			M.	2077	8·4
			M.	2132	8·4
054319	V 21 = SU Tauri.	5	M.	before 1686	9·4
060547	V 19 = SS Aurigae.	4	M.	1675	10·8
074922	U Geminorum.	21	M.	before 1959	9·4

CHAPTER IV.

Derivation of new elements.

As may be seen from inspection of the seventh column of Table I, Hartwig's ephemerides generally can no longer be regarded as representing the actual light variations; as in some cases the O—C amount to more than one half of the period (R Aquilae, R Cancri). Sometimes it was obvious, that this was caused by the provisional character of the formulae. Therefore new elements have been computed for these variables, and for this purpose the observations of the writer were combined with all the material available. Herefore were used the resources of the A. G. Catalogue by Müller and Hartwig, which gives all information up to 1915. The Maxima and Minima stated there were always used with equal weight and only rejected when they were evidently based on too few observations as f. i. Hartwig's observ. of X Camelop. where he derives 5 Maxima and 2 Minima from 12 observations, scattered over a time not less than 25 periods. For data after 1915, the observations compiled by Leon Campbell in H. A. 79, I, the monthly reports of the American Association of Variable Star Observers (A. A. V. S. O.) in Popular Astronomy and the Astr. Nach. (Bd. 200—211) were consulted. The last observations used are from Dec. 1920.

From these data, the period and zero epoch (the arithmetical mean of all epochs was taken as zero epoch) were computed by means of least squares and the results are

stated briefly, for each star separately, below, but a more extensive discussion will be published in "Annalen". In two cases only, the writer did include a periodic term in the formula, but these are only given to explain the observations and are not thought to have any weight for extrapolation, although they decrease the O—C largely.

For each star are given: the mean magnitude attained at Max. and Min., the shape of the lightcurve, following the classification of H. A. 57, I, the old and new elements and the number of maxima and minima used in the computation.

1) 004535 V 10 = RR Andromedae.

$9^{m}.5 - 14^{m}.0$. Uniform variation.

Old Elements: M = 2415824 + $333^{d}.5$ E M — m = 179^{d} (PRAČKA).
New ,, M = 2418474 + 330.5 E M — m = 162.

For the computation were used.

20 Maxima from J. D. 2415502 to 2421767 and
20 Minima ,, 2415598 ,, 2421610.

2) 022980 V 10 = RR Cephei.

$10^{m}.0 - 14^{m}.0$ Broad Minima.

Old Elements: M = 2416334 + 382^{d} E. .... (HARTWIG).
New ,, M = 2419761 + 382 E.

14 Maxima used from 2417480 — 2422446.

3) 043274 X. Camelopardi.

$8^{m}.2 - 12^{m}.8$ Uniform variation? broad maxima?

Old Elements: M = 2416269 + $141^{d}.5$ E M — m = 80^{d} (PRAČKA).
New ,, M = 2420094 + 142·2 E M — m = 65^{d}

32 Maxima used from 2416825 — 2421949
25 Minima used 2416326 2422017

4) 060450 X Aurigae.

$8^m\!\cdot\!2$—$12^m\!\cdot\!8$ Uniform variation? broad maxima?

Old Elements: $M = 2415940 + 162^d\!\cdot\!6\,E$ $M - m = 80^d$ (Nijland).
New „ $M = 2419209 + 164\cdot 2\,E$ $M - m = 77^d$

41 Maxima used from 2415130 — 2422495
39 Minima 2415868 — 2422560

5) 064030 X Geminorum.

$8^m\!\cdot\!2$—$13^m\!\cdot\!3$ Uniform variation.

Old Elements: $M = 2398982 + 263\cdot 0\,E$ $M - m = 145^d$ (Hartwig).
New „ $M = 2418692 + 263\cdot 1\,E$ $M - m = 127$
or $M = 2421060 + 263\cdot 1\,E$
$+ 18 \sin 16^\circ\!\cdot\!5\,E$

25 Maxima used from 2414749 — 2422400
18 Minima 2415125 — 2422275

6) 131546 V Canum Venaticorum.

$6^m\!\cdot\!8$ — $8^m\!\cdot\!6$. Rapid increase.

Old Elements: $M = 2420333 + 192^d\!\cdot E$ .... (Zinner).
New „ $M = 2421092 + 193\,E$ $M - m = 79^d$.

6 Maxima used from 2418964 — 2422064.
4 Minima 2421406 — 2421960.

7) 133273 T Ursae Minoris.

$9^m\!\cdot\!6$ — $13^m\!\cdot\!8$. Broad Minima.

Old Elements: $M = 2416969 + 317^d\!\cdot\!0\,E$ $M - m = 133^d$ (Müller).
New „ $M = 2419495 + 314\cdot 3\,E$ $M - m = 135$

18 Maxima used from 2416973 — 2422314.

8) 154536 X Coronae.

$9^m.0 - 14^m.0$. Uniform variation.

Old Elements: $M = 2417687 + 243^d$ E $M - m = 100^d$ (PRAČKA).

New ,, $M = 2419849 + 238 \cdot 4$ E $M - m = 101$

22 Maxima used from 2417432 — 2422462.

18 Minima 2417360 — 2422375.

9) 160325 V 24 = SX Herculis.

$8^m.0 - 8^m.8$.

Old Elements: $M = 2418090 + 100^d.55$ E $M - m = 54^d.6$ (LUIZET).

New ,, $M = 2419884 + 99 \cdot 6$ E $M - m = 50$

13 Maxima used from 2418091 — 2422071.

15 Minima 2418041 — 2422037.

10) 162807 V.19 = SS Herculis.

$8^m.8 - 12^m.2$. Uniform variation.

Old Elements: $M = 2416951 + 103^d.9$ E $M - m = 52^d$ (GRAFF).

New ,, $M = 2419957 + 108 \cdot 26$ E $M - m = 48$

or $M = 2420498 + 108 \cdot 26$ E

$+ 10 \sin (9°25$ E)

29 Maxima used from 2417050 — 2422128.

30 Minima 2416804 — 2422183.

11) 165631 V 14 = RV Herculis.

$10^m.5 - 14^m.2$. Uniform variation.

Old Elements: $M = 2414352 + 204^d05$ E $M - m = 93^d3$

New ,, $M = 2418248 + 205 \cdot 81$ E $M - m = 89$

38 Maxima used from 2414160 — 2422565.

34 Minima 2414260 — 2422489.

12) 181103 V 17 = RY Ophiuchi.

$8^m.2 - 13^m.0$. Uniform variation.

Old Elements: $M = 2417817 + 153^d.3$ E $M - m = 76^d$ (GRAFF).

New ,, $M = 2419773 + 150 \cdot 62$ E $M - m = 70$

21 Maxima used from 2431760 — 2422483.

Summary of results.

Star.	M. (Mean).	m. (Mean).	Elements.	M—m.
V 10 = RR Andromedae.	$9^m.5$	$14^m.0$	$M = 2418474 + 330^d.5\ E$	162^d
V 10 = RR Cephei.	10·0	14·0	$M = 2419761 + 382^d.\ E$	—
X Camelopardi.	8·2	12·8	$M = 2420094 + 142^d.2\ E$	65
X Aurigae.	8·2	12·8	$M = 2419202 + 164^d.2\ E$	77
X Geminorum.	8·2	13·3	$M = 2418692 + 263^d.1\ E$ $= 2421060 + 263.1\ E$ $+ 18 \sin (16^\circ.5\ E)$	127
V Can. Ven.	6·8	8·6	$M = 2421092 + 193^d.\ E$	79
T Ursae Min.	9·0	13·8	$M = 2419495 + 314^d.3\ E$	135
X Coronae.	9·0	14·0	$M = 2419849 + 238^d.4\ E$	101
V 24 = SX Herculis.	8·0	8·8	$M = 2419884 + 99^d.6\ E$	50
V 19 = SS Herculis.	8·8	12·2	$M = 2419957 + 108^d.26\ E$ $= 2420498 + 108.26\ E$ $+ 10 \sin (9^\circ.25\ E)$	48
V 14 = RV Herculis	10·5	14·2	$M = 2418248 + 205^d.81\ E$	89
V 17 = RY Oph.	8·2	13·0	$M = 2419773 + 150^d.62\ E$	70

CHAPTER V.

Cepheids and Eclipsing Variables.

The method of observing for these stars was the same as for the previous ones, NYLAND's interpolation method, cited above, being almost exclusively used. For V 18 = RZ Cephei, a series of photographic observations, made at the Royal Observatory, Greenwich, is also included (cf. M. N. LXXXI, 398).

The details about the comparison stars used, and the derivation of their magnitude, will be found in „Annalen", where also the whole of the observations will be printed. In the case of these stars, the table of observations includes three columns viz. 1: Date of observation to hundredths or thousandths of a day (Hel. G. M. T.), 2: Phase, counted from J. D. 2422200·000 (Hel. G. M. T.) as arbitrary common zero point, and in the same decimals as the date, and 3: the Magnitude derived.

The mean light-curves for the Cepheids, deduced from these data, are also shown there; except for S Sagittae, it was nowhere found necessary to assume fluctuations in the curve. For the eclipsing variables the number of observations was generally too small to show the whole curve, therefore only the times of minimum have been derived.

In this abstract, only a normal Maximum and Minimum, also the times, at which the variable attained its median and mean magnitude, together with their respective magnitudes are given for the Cepheids. The median magnitude is defined

in the following way: when a parallel to the abscissa-axis is drawn through an ordinate, equal to this median magnitude, the areas between the lightcurve and this line above and beneath it are equal. The mean magnitude is simply the mean of maximum and minimum. Both have been given as they differ sometimes very materially (T Monocerotis, broad minimum). For the Algol-variables only a normal minimum together with the maximum and minimum light is tabulated. All of this will be found in Table III at the end of this chapter.

A few particularities of some stars might be mentioned here, viz.

1) ζ Geminorum.

From the observations of HEIS, ARGELANDER, PICKERING, LUIZET, HORNIG, VOGELENZANG[1]) and the writer, it was found that the lightcurve of this star can practically be represented by a sine curve. For, when harmonic analysis is applied to the observations of all these observers, the coefficient of the second harmonic is quite inappreciable and smaller than its mean error, in fact it is

$$-{}^{m}_{\cdot}0032 \sin\theta \;(\pm{}^{m}_{\cdot}0039) + {}^{m}_{\cdot}0007 \cos\theta \;(\pm{}^{m}_{\cdot}0039),$$

θ being the time measured in terms of the period. When the lightcurves of all different observers are reduced to the writers amplitude, the result reads (reduced to the writer's mean epoch)

$$\begin{array}{ll} Y = 3^{m}_{\cdot}938 - {}^{m}_{\cdot}165 \sin 35^{\circ}_{\cdot}4 \;(T - 2421115^{d}_{\cdot}05) \\ \quad \pm \cdot 005 \pm \cdot 008 \qquad\qquad\qquad\qquad \pm \cdot 06. \end{array}$$

2) V 21 = SU Cygni.

The large discordance between the observations and the prediction by LUIZET, (Astr. Nach. 4141), O—C being $-{}^{d}_{\cdot}26$

1) Kindly supplied by Mr. VOGELENZANG in M.S.

led the writer to deduce a new formula for this star. For this were used all the series mentioned in LUIZET's paper, the complete discussion wll be found in „Annalen".

LUIZET's Elements $M = 2414202{\cdot}820 + 3{}^{d}_{\cdot}845623\ E \quad M - m = 1{}^{d}_{\cdot}29$
New „ $M = 2416117{\cdot}96 \ \ + 3{\cdot}845472\ E$
$\pm {\cdot}045 \pm {\cdot}000094.$

There is a large difference in the shape of the lightcurve as found by different observers. When the curves of MÜLLER & KEMPF, VON PRITTWITZ, LUIZET, LUYTEN, (all visual) and WILKENS (photographic) were all reduced to the same amplitude $0^{m}_{\cdot}75$, the first two proved to be almost identical, also the second two, while at the same time these last ones very closely resembled to the fifth. It is perhaps best illustrated by the value of M — m, the mean of M & K and v. P. is 0·256 periods, for L — L 0·335 and for WILKENS 0·331. Happily it seems, that this difference is almost wholly due to the place of the minimum, and so the maximum could be used for determining the period, without further reduction.

3) V 10 = RR Lyrae.

About 200 observations of this variable, scattered over 1500 periods were reduced to one epoch by means of the adopted period $0{}^{d}_{\cdot}566826$ (HARTWIG's Vierteljahrsschrift). As the result was a lightcurve, perfectly symmetrical, with respect to the Maximum, it might be suggested, that the period was not constant during the interval of observation. Therefore the observations only, are printed in "Annalen" and no normal maximum has been derived from them.

Table III may be briefly explained here:
The first three columns give the name of the star, the

number of observations and the mean epoch of observation, the next three the maximum and minimum brightness and the range. Then follow the time of Maximum and Minimum reduced to mean epoch, while the next four give the median magnitude and the time it is reached on the ascending branch of the curve and the mean magnitude with its corresponding time. Next are the Max. and Min. reduced to the epoch 2422200; the last column gives the period used.

TABLE III.

STAR.	N°. Obs.	Mean Epoch 242	Max.	Min.	Range	At Mean Max. ⊙ G. M. T.	Epoch Min. ⊙ G. M. T.	Median Magn.	Time. 242	Mean Mag.	Time. 242	Max. 2422200 + (⊙ G. M. T.)	Min. 2422200 + (⊙ G. M. T.)	Period.
T Monocerotis......	132	1130	$5^m.90$	$6^m.73$	$^m.83$	1141·85	1133·51	$6^m.44$	1139·29	$6^m.32$	1140·83	22·34	14·0	$27^d.0122$
V 12 = RT Aurigae..	171	1175	5·07	5·40	·33	1177·42	1176·35	5·31	1176·85	5·24	1177·09	02·67	01·60	3·7282
ζ Geminorum.......	126	1120	3·74	4·11	·37	1127·74	1122·67	3·92	1120·13	3·92	1120·13	14·20	09·13	10·1538
V 21 = SU Cygni....	197	1475	6·37	7·02	·65	1478·45	1477·18	6·72	1477·90	6·70	1477·94	01·43	00·16	3·845472
η Aquilae	246	1390	3·76	4·27	·51	1394·16	1391·69	4·04	1393·08	4·02	1393·26	05·10	02·63	7·1764
S Sagittae	255	1370	5 43	5·94	·51	1371·38	1368·8	5·70	1370·38	5·68	1370·46	01·16	*98·6*	8·381613
T Vulpeculae.......	280	1380	5·77	6·27	·50	1381·43	1380·0	6·05	1380·89	6·02	1380·93	02·00	00·6	4·435521
δ Cephei............	630	1430	3·71	4·24	·53	1439.71	1429·27	4·02	1430·21	3·98	1430·27	03·47	02·03	5·366346
V 18 = RZ Cephei...	87	1500	9·17	9·65	·48	1500·028	1499·928	9·43	1499·976	9·41	1499·978	00·023	*99·923*	0·30864
„ (photo)	135	2190	*9·16*	*9·87*	*·71*	2190·199	2190·125	*9·54*	2190·169	*9·52*	2190·170	00·074	00·000	0·30864
u Herculis..........	316	1240	4·70	5·45	·75	1242·970	1241·427	—	—	—	—	—	—	2·051020
			4·70	4·90	·20	1241·973	1240·433	—	—	—	—	—	—	—
β Lyrae	407	1410	3·45	4·18	·73	1407·8	1411·15	—	—	—	—	—	—	12·914989
			3·45	3·60	·15	1401·8	1404·8	—	—	—	—	—	—	—
Z Vulpeculae.......	67	1160	7·23	8·27	1·04	—	1159·980	—	—	—	—	—	00·866	2·45492
U Cephei...........	50	1160	6·98	9·29	2·31	—	1157·450	—	—	—	—	—	01·967	2·4928840
V18 = RZ Cassiopejae	65	1130	6·37	7·46	1·09	—	1132.422	—	—	—	—	—	00·976	1·19525
β Persei	81	1130	2·27	3·49	1·22	—	1131·654	—	—	—	—	—	—	2·86
U Sagittae.........	103	1180	6·53	9·46	2·93	—	1180·404	—	—	—	—	—	01·345	3·380603
V 11 = RS Vulpeculae	43	1202	6·72	7·64	·92	—	1202·155	—	—	—	—	—	00·689	4·47773

CHAPTER VI.

On the change of period of longperiod variable stars.

By inspection of the column O — C in the table of Maxima and Minima, according to my observations, perhaps the most striking feature is, that the negative residuals predominate. In fact there are $45^1/_2$ positive and $90^1/_2$ negative residuals, so there is the same probability for this not being accidental, as for an error occurring, which is 3·86 times the mean error.

There are several possible explanations for this effect,

1. Personality in drawing the lightcurve and deriving the times of Maximum from it.
2. The periods of the majority of long period-variable stars are decreasing.

The first explanation is rendered improbable by the fact, that a comparison of the writer's data with those of other contemporary observers shows no systematic differences (see f. i. NIJLAND's paper in Astr. Nach. 4912).

It was by the second alternative, that can hardly be expected to be right, that the writer was led, in view of Prof. TURNER's papers about this subject in M. N. LXXX pp. 273, 481, 604, to examine some of these stars, that have been known for a long time.

The following stars, which have all been observed for more than 60 periods have been selected: R Aquilae, R Cancri, R Virginis, R Camelopardi, S Ursae Majoris, R Leonis,

R Ursae Majoris, χ Cygni, R Vulpeculae, R Arietis, T Geminorum, R Cygni, S Cygni, T Ursae Majoris, R Cassiopejae, R Serpentis, T Herculis and R Persei. R Hydrae has not been included, as for this star the secular decrease of period has been thoroughly established and the star has been extensively treated by LUDENDORFF in Astr. Nach. 4856. Only the maxima have been used for the investigation as for most of the stars the minima are not well observed, and are subject to larger errors than the maxima. These data were collected from the compilation by Miss CANNON in H. A. 55, II, completed to 1915 by the A. G. Catalogue of MÜLLER and HARTWIG, and after that date, from the observations printed in Popular Astronomy and NIJLAND's papers in Astr. Nach. The latest maxima used are from 1920.

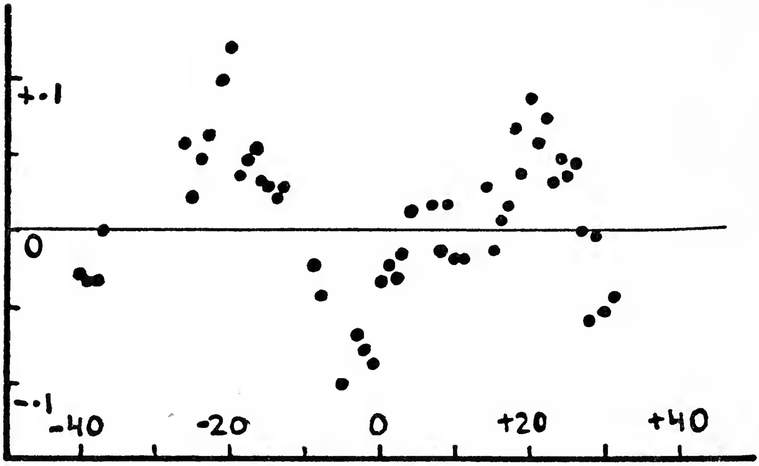
In order to discuss the deviations from a regular period, a linear ephemeris was calculated according to least squares. To facilitate the computation a rough ephemeris was first calculated with approximate period and zero epoch. From the differences with this provisional ephemeris, the corrections of this period and epoch were found. The final O — C with this second ephemeris were then plotted in the way as was already done by PHILLIPS (J. B. A. A. XXVII, 1). Only now, the number of epochs elapsed, was taken as abscissa and the O — C in decimal parts of the period as ordinates, the same scale being used for all stars.

We will now proceed to a detailed description of the graphs for the individual stars, giving the general conclusions at the end, and will begin with the most striking, disregarding R Hydrae, for the reasons mentioned above.

1) R Aquilae.

It has long been known, that the period of this variable was decreasing: this is well shown in the diagram (Plate I).

A parabola has accordingly been laid through these points and the O — C still left, are shown in the accompanying figure.



As one sees from this, the introduction of a cubic term in E will, at present, not sensibly improve the representation of the observations; neither is there any need to add a sine term like HARTWIG does. In the A. G. Catalogue, MÜLLER derives the following elements from observations up to 1915.

$$\text{Max.} = 2404345 + 340^{d}.27\ E_1 - 0^{d}.2928\ E_1^2 + 0{\cdot}00118\ E_1^3$$

and accordingly his period decreases from

354 days in 1851 ($E_1 = -20$) to 318 days in 1924 ($E_1 = +60$).

The new formula, for which all Maxima up to 1920 are used, reads

$$\text{Max.} = 2412693 + 328^{d}.29\ E - 0^{d}.2392\ E^2$$

or reduced to MÜLLER's epoch

$$= 2404336 + 340^{d}.25\ E_1 - 0^{d}.2392\ E_1^2$$

indicating a decrease of period of

350 days in 1851 to 313 days in 1924.

Turner discusses this star in M. N. LXXX, 279 and finds four sudden changes of period, occurring respectively at $E = -15, +5, +32, +44$ (according to the above formula) and his residuals O — C, are much smaller than those obtained with a uniformly decreasing period. Also his prediction of a Max. at 2422643 is very close to the observed one, viz. 2422625.

In view of sudden changes being nowhere firmly established, the writer still feels inclined to think that the hypothesis of a uniformly decreasing period is closer to the truth.

2) R Cancri.

When the last four maxima are omitted, a simple sine term, added to the period, will accord beautifully with the observations; to do so now, the period would have to be decreased a little.

We do not know, how many epochs ago occurred the first maximum, observed by Schwerd. If $E = -57$, as adopts Harvard, O — C is nearly zero, but if $E = -58$, O — C becomes + 1·0 so that the point would come on a straight line with the first 20 points.

3) R Virginis.

Of all the stars in the diagram, except Mira Ceti, this star has been known for the largest number of periods (280). The actual differences with the constant-period-ephemeris amount to over a quarter of a period.

Two straight lines intersecting at about $E = 18$, or a sine curve with its maximum at that point, accord about as well to the observations. The first and last groups of points, however, seem to indicate, that the sine curve represents the observations better at present, but any extrapolation from this formula is of very problematic value.

The sine-term formula, used by Hartwig for his ephemeris,

is evidently wrong as the star is now a fourth of its period earlier.

4) S Ursae Majoris[1]).

The curve has the same general appearance as for R Cancri. The later, descending, branch of the curve is remarkably straight. It indicates, that the period was almost constant during the corresponding time and 2 days shorter than the computed mean period.

Besides a sudden change in period at E = + 3, Prof. TURNER adopts still two more jumps in period at E = — 28 and — 12, while one change at E = — 22 would leave little more in the differences O — C than may be taken as accidental errors. Furthermore, he admits a change in epoch at E = — 43: this seems to be more than can be concluded with any evidence from the diagram.

His conclusion however: oscillation with secular increase (l. c. p. 495) seems to be premature. For, as he says himself: had this variable not been discovered before 1869, the figures would have suggested a secular *decrease* of period. But now suppose, the variable had been discovered about 1820 and between 1820 and 1843 there had been a sudden change like there is now at E = + 3, which is quite possible. Then TURNER could have claimed a "pretty certain" secular decrease of the period.

In the present state of affairs, I think we have no right to conclude about secular changes of period, as long as there are (much larger) sudden jumps. Only if many stars having jumps in the periods, show such a tendency to secular in-

[1]) There is a misprint in H. A. 55 about this star; the residual for the third maximum should read 42 instead of *42*. This also escaped TURNER's notice; when it is applied to his computation his residual — 76 improves to + 8.

crease we could say, that, statistically the stars tend to increase their periods.

The only two stars, for which, up to now, such a secular change has been firmly established, are R Hydrae and R Aquilae, both decreasing.

5) R Serpentis.

Inspection of this diagram does not show any secular increase of period as suggested by TURNER. In the beginning there are large oscillations but these flatten out in the end.

6) R Camelopardi.

The diagram resembles to some extent to that of R Cancri and S Ursae Majoris. Not much is shown of "breaks at every 9 cycles, not always taken" as suggests TURNER (M. N. LXXX, 491) and especially with regard to the observations after $E = + 19$, it seems not allowed to conclude to a secular increase

7) R Arietis.

For this star all the $O - C$ are smaller than a tenth of the period, so we can say that there were hardly any perturbations of the period during the time covered by the observations. But this is too uncertain to draw conclusions from. At any rate TURNER's conclusion: "in any case a slight increase of period is suggested" (l. c. p. 495) cannot be approved with.

8) R Vulpeculae.

The diagram does not bear any evidence to TURNER's assumption of breaks at $E = - 26$ and $+ 33$; if such break occurred, it is more likely that it took place at $E = - 69$, $- 15$, $+ 22$. But, like for the previous star, there is no indication of secular increase.

9) T Herculis.

Not much is shown of sudden changes in period as supposed by Turner; in fact, the only one, more or less clearly indicated here, (at E = — 20) is just the one of which he is not sure. His changes should occurr either at — 80, — 48, — 21, + 5, or at — 60, — 44, — 27, + 5, + 21. His conclusion about a secular increase in either case, is premature and is certainly not supported by this diagram.

10) χ Cygni.

This star has been observed for more than 200 of its periods, but does not show very much interesting. From the beginning to E = + 20, a constant period, slightly (0·6 days) less than the mean one, accords well with the observations, leaving only large residuals at E = — 66, — 65. — 64. After E = + 20 the period is markedly larger than before and the change is rather sudden, while against the end period shows again a tendency to decrease.

There seems no reason to admit jumps in epoch, exept perhaps for the three discordant epochs mentioned above: but these are just the ones, that are disregarded by Turner (M. N. LXXX, 282) as they are of one observer (Le Gentil). On the other hand he admits a jump for each of the two groups of 4 maxima E 26 — 29 and 30 — 33, for which the diagram does not show much evidence. Other jumps in epoch are supposed by Turner at E = + 33 and + 51.

It is remarkable, that, where Turner, following the line used in his discussion in M.N. LXXX 481 should obviously arrive again to the conclusion: oscillation with secular increase, (for his data do not extend beyond E 69) he does not draw this conclusion, but on the contrary states, that: "the main point seems clear, viz. no increase of period is in evidence."

11) o Ceti.

This is the longest known of all variables and has been observed through more than 350 periods, but as it is practically inobservable from March till July, there are large gaps in the records. The diagram shows large fluctuations, the O — C mounting up to a fifth of the period, but apparently without conspicuous regularity. The writer should be inclined to think, that the period changes continuously and not abruptly like TURNER suggests, although the latter finds remarbable regularities in these changes. That, under his assumptions, the O — C lose their systematic character, is not astonishing, in view of the several constants at disposal in TURNER's representation of the observations.

12) R Ursae Majoris.

This star is a good example, how dangerous it is, to draw conclusions of the kind here regarded. From this diagram it is seen, that a parabola, indicating a uniform decrease of period would sensibly decrease the residuals O — C. If, on the other hand we take PHILLIP's diagram (J. B. A. A. XXVII, 19) where the latest maxima are not included, a decrease of the period is much less conspicuous. If however, we make the same diagram with the minima, we get practically a confirmation of the one shown here, so that after all, the decreasing of the period may not be a deception.

13) T Ursae Majoris.

The diagram for this star is not very striking, and there does not seem to be any reason for suggesting sudden changes of period.

14) R Leonis.

Perhaps the star, most suggestive of adopting a sudden change of period; f. i. the sharp bents at $E = +19$ and

E + 38. Another one might be supposed to have occurred at E = — 94, thus indicating that the number of cycles after which a jump is liable to occurr can be 19, instead of 16 as adopted by Turner.

15) R Cygni.

Only one change is indicated here, viz. at E = + 16, but the material is too scanty, to draw trustworthy conclusions.

16) S Cygni.

Just as for R Cygni, only one abrupt change is seen in the diagram at E = + 10 but there is evidently no need, to admit sudden jumps in epoch as supposed by Turner. (M. N. LXXX, 283). It would be interesting however, to examine the lightcurve in the neighbourhood of such a place; if a jump in epoch is present, it must be clearly shown in the curve. There is no evidence for a secular decrease of period (l. c. p. 289).

17) T Geminorum.

A parabola with the + axis downwards would diminish the differences O — C very little and thereforeno conclusion as to a secular decrease of the period can be safely drawn.

18) R Cassiopejae.

This star and R Cancri are the only ones, where a sine term would, as far as the observations go, give a considerably better representation of the observations. But we can just as well suppose two jumps in the period E = — 10 and + 13.

19) R Persei.

Turner suggests (M. N. LXXX, 492) three jumps in the period viz. at E = — 43 — 19, + 5, (Turner E =+7, + 31,+55)

none of which is shown in the diagram here. From this can only be read a sudden change at $E = -35$. In any case it is obvious, that we cannot suppose the period to be increasing as does TURNER, even not when we omit all observations after $E = +25$, that were not known to TURNER.

Coming now, to drawing general conclusions from the diagrams represented here, we must first consider what alternatives for explanation are open for us to choose between.

In the main line following PHILLIPS (J. B. A. A. XXVII, 22) the writer would formulate the three different possibilities as follows: The deviations of the times of maximum from a linear ephemeris can be:

(*a*) Satisfactorily represented by a few sine terms, as was done by ARGELANDER and CHANDLER.

(*b*) They can be explained by abrupt changes in period. TURNER suggests, that these occurr at regular intervals, combined with occasional jumps in epoch at irregular times.

(*c*) They show continuous changes of an irregular character.

PHILLIPS himself says, that there cannot yet be decided between these three hypotheses, although he thinks that "the difficulties risen against (*a*) appear to be overwhelming."

From the diagrams represented here, we can draw the following conclusions to extend his statement.

(1) The first explanation may now be regarded as excluded.

(2) None of the graphs shows exclusively straight lines, though they may occurr on some.

It may therefore at least be said that (*b*) is very improbable. The close agreement with the observations produced by TURNER, in applying this method can be explained by the large number of constants at his disposal, as is said before.

(3) So we are led to believe that (*c*) is the only possible alternative to accept at present.

We will now proceed to see, whether there is to be detected any connection between the results found here, and PHILLIPS' division into two groups, (like suggests TURNER). PHILLIPS (J. B. A. A. XXVII N^0. 1) divides the long period variable stars into two groups, according to the results he derives from harmonic analysis of their lightcurve.

He takes 180° as the phase of the first harmonic and uses the phases of the second and third harmonic, thus found, as coördinates to represent the stars in a diagram.

He then finds, that, "instead of forming one system, they fall into two distinct groups" (l. c. p. 5).

HAGEN showed (Ap. J. LIII, 179) that this classification corresponds to the separation of the stars with "uniform variation" (HARVARD Annals Vol. 57, I) which should form PHILLIPS' group I, from those with "broad minima" or "rapid increase", (PHILLIPS' group II, subdivided by HAGEN into II*a* resp. II*b*).

It is the place here, to quote a remark of Dr. O BIRCK of Potsdam, made in a letter to Prof. HERTZSPRUNG viz. that, if in PHILLIPS' diagram (l. c. page 6) all the phases Φ_3 of the stars belonging to group II are increased by 360° like PHILLIPS has already done for Φ_2 the falling into two groups disappears.

As is seen below from fig. 1, which is drawn according to BIRCK's suggestion, we can say that now group II appears more less as an extension of group I. But there is still a kind of sudden change in the curve laid through all the points, which however, might disappear when more stars are used.

In the diagram are inserted as ordinary dots, the six stars, which are called doubtful or discordant by PHILLIPS and represented by him by crosses; also the two stars V Andro-

medae and T Draconis, which were missing in his diagram, as Birck also remarked.

An objection is, that Phillips does not give the mean

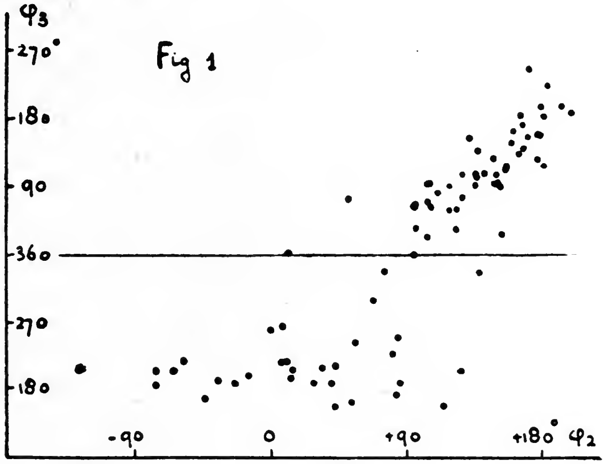


Fig 1

errors of his Φ_2 and Φ_3; if these are taken into account, each star would be represented by an ellipse and we cannot say what aspect the diagram would then have.

Let us suppose for the moment, that the division in two groups is real, and see, what conclusions we can draw from our diagrams. With this in view, considering them together, we note the fact that, out of these 19 stars, one shows a well established secular decrease of period, as far as the observations go (R Aquilae) two may be suspected of it (R Ursae Maj. T Geminorum), while eleven others also end with negative residuals and five with positive. Of these 14 stars ending with negative residuals, 9 belong to group II and 5 to group I.

If we arrange the stars according to their group, we get the following table.

Group I.		Group II.	
R Arietis	—	o Ceti	—
R Leonis	+	R Persei	—
R Verginis	—	T Geminorum	—
S Ursae Majoris	—	R Cancri	—
R Camelopardi	—	R Ursae Majoris	—
R Serpentis	+	T ,, ,,	—
T Herculis	+	R Hydrae	—
(S Cygni	—)	R Aquilae	—
R Vulpeculae	+	R Cygni	—
		R Cassiopejae	—

R Hydrae has been inserted, although its diagram is not reproduced here: χ Cygni, for which it is doubtful, to which group it belongs has + last residuals. S Cygni is placed between brackets on account of its broad minima, according to which Hagen classifies it as group II. From the shape of its lightcurve T Geminorum has been assigned to group II by the writer.

We see that of the 10 stars belonging to group II, none shows + last residuals, while of group I four are + and five —.

The probability that all + signs fall together in group I s $^1/_{16}$, but this does not give a true idea of the state of things as the — signs are then totally disregarded.

The material is too scanty, to conclude anything about the relative size of the oscillations of stars belonging to either group, although the diagrams seem to be rather in favour of larger oscillations for group I.

If we treat the 136 stars for which the writer's maxima and minima are given in Chapter III, Table I in the same way we find that for 69 stars the group is given by Phillips.

Of these:

26 belong to group I showing 16 — and 10 + residuals
34 ,, ,, ,, II ,, 27 — ,, 7 + ,,

while of the 5 stars for which the group is doubtfull (χ Cygni, RV Herc., V Cygni, T Aquarii, T Hydrae) 3 are — and 2 +

Again we see the relative excess of negative values in group II when compared with group I.

The probability that this excess is due to chance distribution is as large as that an error occurring, which is 3·5 times the mean error.

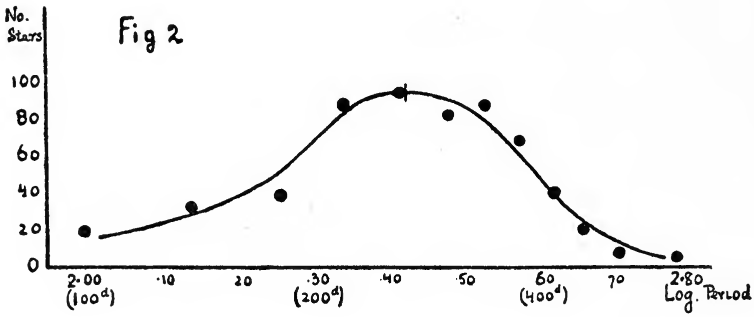
We may therefore say, that the stars of group II are probably generally decreasing in period, while for the stars of group I there is no evidence of systematical change of period. TURNER's suggestion, that increase of peroid predominates among stars of group I. is in no way supported.

In the mean the periods of group II are longer than those of group I and thefore our 136 stars were arranged in order of their length of period, to see whether there was any run in the sign of the residuals with the period, the residuals getting more frequently negative the larger the period. The table underneath shows that this is not the case.

Limits of period	Number of residuals —	+
	12	7
200^d		
	13	10
250		
	18	10
300		
	23	6
350		
	17	5
400		
	$8^1/_2$	$13^1/_2$

One can certainly not conclude herefrom, that the *longer* periods are *decreasing*.

Phillips notes the „significance of the fact, that out of six stars with period under 200 days, 5 belong to group I, the simple exception, S Scorpii, is also the extreme case in the table of ranges and it seems likely that the star is wrongly classed". This is indeed not unlikely, as the coefficient of the third harmonic is only $^{m}.04$! It is worth mentioning here, that these stars seem to be relatively much more numerous than formely supposed, which may be seen from fig. 2, in which are shown the frequencies of different



periods. In this diagram are represented all the 576 stars for which periods are stated in „Vierteljahrsrchrift der A. G. 53er Jahrgang 4es Heft, and the relative frequency is plotted against the logarithm of the period. It shows, that the most frequent period is about 280 days whereas, formerly 330 was usually adopted. It would be interesting to examine the lightcurve of all the stars with periods less than 200 days, to see whether really group I is favoured by them in the mean.

Summary of the results.

Nineteen well observed stars have been examined for changes of period, with the result that, besides R Hydrae, not treated here, one secular decrease was definitely confirmed, (R Aquilae) and two very much suspicious ones (R Ursae Majoris and T Geminorum) found.

Holding to Phillips' division into two groups, the evidence seems generally in favour of a shortening of the period for stars of group II, while the sign of an eventual secular change in period is as yet wholly uncertain for the stars of group I.

Sudden jumps in the period have not met with much support, jumps in epoch are almost excluded.

STELLINGEN.

I.

De door Turner aangenomen sprongsgewijze veranderingen in de epoche en de periode van lang-periodieke veranderlike sterren, zijn door hem niet voldoende gerechtvaardigd.

M. N. LXXVI, 185, LXXX, 273, 481, 604.

II.

Turner's onderstelling, dat de periode van sommige sterren van Phillips' groep I toeneemt, is aan ernstige bedenkingen onderhevig,

M. N. LXXX, 481.

III.

Uit de vergelijking met een lineaire ephemeride, van alle maxima van lang-periodieke veranderlike sterren, die lang waargenomen zijn, schijnt te volgen, dat hun perioden in 't algemeen aan verkorting onderhevig zijn.

IV.

Het verschijnsel, dat de zonnevlekken enige neiging vertonen, geruime tijd achtereen bij voorkeur te verschijnen omstreeks een bepaalde, en evenzo omstreeks een diametraal tegenovergestelde meridiaan, geeft kans op inzicht in het wezen van de veranderlikheid der sterren.

WOLFER, Astr. Mitt. CVIII. 197.

V.

De beschikbare stertellingen geven geen recht om een zo ongelijkmatige verdeling der sterdichtheid in galaktiese lengte aan te nemen, als vereist zou worden door een dermate excentriese positie van de zon, als SHAPLEY en PANNEKOEK onderstellen.

SHAPLEY, Mt. Wilson Contr. 152, 157.
PANNEKOEK, M. N. LXXX, 7.

VI.

SCHOUTEN's opmerking dat SHAPLEY ten onrechte de door LEAVITT voor gewone Cepheiden gevonden betrekking tussen Mabs en log. periode heeft uitgebreid tot veranderliken van het z. g. clustertype, ontneemt de voornaamste steun aan SHAPLEY's buitengewone afstandsschattingen in het sterrenstelsel.

SHAPLEY, Mt. Wilson Contr. 151.
SCHOUTEN, Hemel en Dampkring, April 1921.

VII.

De methode welke Aitken aangeeft voor het berekenen van correcties voor de baanelementen van een dubbelster, is in strijd met zijn eigen bezwaren tegen de methode van Sir John Herschel.

The Binary Stars p. 93 en 71.

VIII.

De formaties op de Maan hebben weinig overeenkomst met vulkaniese landschappen op aarde of met een door granaten doorploegd terrein.

Ives, Ap. J. L, 245.

IX.

De in Greenwich voor parallax-metingen gebruikte "occulting shutter", kan met succes worden toegepast bij de vergelijking van de fotografiese magnitude van sterren, die zeer veel in helderheid verschillen.

M. N. LXXXI, 61.

X.

Een uitdrukking, die dienst moet doen om het „nuttig effect" van een waarnemingsmethode aan te geven, moet noodzakelikerwijs invariant zijn voor orthogonale substituties. Het kenmerk van Bruns, hoewel hieraan voldoende, is in de praktijk niet bruikbaar, terwijl dat van Loewy er alléén aan voldoet onder de voorwaarde, dat de te meten grootheden in onafhankelike normaalvergelijkingen gevonden worden.

Bruns, Astr. Nach. 3098.

Loewy, Ann. Paris Mém. XXVII, A 8.

XI.

Voor de stelling, dat het evenwicht stabiel is, wanneer de potentiële energie een minimum is, verdient het bewijs, in de vorm zoals APPELL dat gegeven heeft, de voorkeur boven dat van WHITTAKER.

APPELL, Méc. Rationelle II, 329.
WHITTAKER, Anal. Dyn. 186.

XII.

Ten onrechte beweert HERTZ, dat het principe van HAMILTON slechts geldt voor holonome systemen.

HERTZ, Prinz. Mech. § 22.

XIII.

Het is hoog tijd, dat Nederland zich bevrijdt uit zijn "non splendid isolation" en eindelik de Greenwichtijd invoert, zich daarbij aansluitende bij de internationale overeenkomst van alle beschaafde landen.